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ABSTRACT

A practicum intervention was designed and implemented over an 8-month period for the purpose of enhancing the mathematics-related cognitive and social interaction skills of primary school students in five kindergarten one pre-first, and seven first grade classrooms. Students interacted in group discussions and activities involving interest centers, brainstorming, and deductive reasoning. Manipulative activities were provided. These included cut-and-paste activities, manipulative games, illustrating activities, and charting activities. Teachers shared ideas that enhanced problem-solving activities. Practicum evaluation data indicated that the intervention was effective in improving students' cognitive and social skills in mathematics lessons. Teachers and parents grew in their ability to facilitate mathematics problem solving. Related materials, including sociogram data, checklists for recording observations on children and teachers, a teacher questionnaire, and checklists on lesson plans and behavior in conferences, are included. (Contains 42 references) (RH)

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Enhancing Mathematics Problem-Solving Skills of Five and Six-Year-Olds Through Explorative Learning Experiences

by

Miranti Rahaju Murphy

Cluster 30

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A Practicum II Report presented to the Ed.D. Program in Early and Middle Childhood in Partial Fulfillment of the Requirements for the Degree of Doctor of Education

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PRACTICUM APPROVAL SHEET

This practicum took place as described.

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This practicum report was submitted by Miranti Rahaju Murphy under the direction of the advisor listed below. It was submitted to the Ed. D. Program in Early and Middle Childhood and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Nova University.

Approved:

November 21, 1990
Date of Final Approval of Report

Georgianna H. Lowen
Dr. Georgianna Lowen, Advisor

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TABLE OF CONTENTS

		Page
ACKNOWLEDGMENT		iii
TABLE OF CONTENTS		iv
LIST OF TABLES		vi
ABSTRACT		vii
Chapter		
I	INTRODUCTION	1
	Description of Work Setting and Community	1
	Writer's Work Setting and Role	2
II	STUDY OF PROBLEM	6
	Problem Description	6
	Problem Documentation	8
	Causative Analysis	11
	Relationship of the Problem to Literature	13
III	ANTICIPATED OUTCOMES AND EVALUATION INSTRUMENTS	22
	Goals and Expectations	22
	Behavioral Objectives	22
	Measurement of Objectives	23
IV	SOLUTION STRATEGY	28
	Discussion and Evaluation of Solutions	28
	Description of Selected Solution	31
	Report of Action Taken	32
V	RESULTS, CONCLUSIONS AND RECOMMENDATIONS	35
	Results	35
	Conclusion	43
	Recommendations	49
	Dissemination	50
REFERENCES		51

Page

Appendices

A SOCIOGRAMS 56

B STUDENT OBSERVATIONAL CHECKLIST 61

C TEACHER OBSERVATIONAL CHECKLIST 63

D TEACHER INTERVIEW CHECKLIST 65

E TEACHER AND EARLY CHILDHOOD FACULTY QUESTIONNAIRES 67

F LESSON PLANS CHECKLIST 70

G CONFERENCE FORM CHECKLIST 72

LIST OF TABLES

Table		Page
1	Kindergarten, Pre-First and First Grade Schedule	3
2	Early Childhood Faculty Questionnaire Results	9
3	Teacher Questionnaire Results	10
4	Measurements and Standards of Achievement in Mathematics Problem-Solving Skills	25
5	Pre/Posttest Comparison of the Test of Nonverbal Intelligence (TONI)	36
6	Sociograms of Student Interactions During Mathematics Lessons	37
7	Student Observational Checklist Class Results	38
8	Teacher Observational Checklist Results	39
9	Teacher Questionnaire Results	40
10	Early Childhood Faculty Questionnaire Results	41
11	Teacher Interview Checklist Results	42
12	Lesson Plans Checklist Results	44
13	Conference Form Checklist Results	45

Abstract

Enhancing Mathematics Problem-Solving Skills of Five and Six-Year-Olds Through Explorative Learning Experiences
Murphy, Miranti Rahaju, 1990: Practicum Report, Nova University, Ed.D. Program in Early and Middle Childhood.
Descriptors: Problem Solving/Critical Thinking/Metacognition/Mathematics/Logical Thinking/Creative Thinking/Early Childhood/Primary Grades/Kindergarten/Education/Manipulatives/Explorative Learning

This practicum sought to enhance cognitive and interactive skills during mathematics problem solving. The primary goal was to provide explorative mathematics lessons which involved skills in brainstorming, interactive learning, deductive reasoning, and cooperative learning. Thus, students would become active initiators of their educational setting.

The writer administered pretests of the Test of Nonverbal Intelligence (TONI) which measures problem-solving abilities. Then, an activity based mathematical program was developed that encouraged learning through interaction, manipulation, and collaboration. The TONI posttest results as well as student/teacher observations and interviews determined the effectiveness of this program.

The positive results of this practicum were revealed in several ways. Anecdotal observations, interviews, observational checklists, and sociograms revealed improved social-communicative skills as well as increased positive attitudes among practicum participants. Pre/posttesting comparisons indicated significant improvements in students' cognitive development. In conclusion, implementation of this practicum showed improvements behaviorally as well as cognitively.

CHAPTER I

INTRODUCTION

Description of Work Setting and Community

The setting of this practicum was an elementary school situated in the southeast region of the United States. This school consisted of 45 faculty members and 798 students. The school was founded in 1960. Its principal promoted freedom of teaching styles, congeniality among staff members and parents, and provision of students' individual needs. All in all, this school demonstrates a professional, cooperative, and friendly atmosphere.

The school building housed 32 self-contained classrooms, an office, lounge area, a cafeteria, a library, a computer lab, a paved physical education area, and two playground areas. Four classrooms made up each wing of the school.

The school offered a variety of special classes and programs. Special classes which were available at the school include: music, media, art, physical education, science, and computers. The school also offered programs, such as speech classes, emotionally handicapped classes, learning disabled classes, dropout prevention, and gifted classes.

The school community consisted of a predominantly White, working class population. The ethnic ratio was approximately 74% White, 13% Hispanic, 10% Black, and 3% Asian.

Writer's Work Setting and Role

The setting of this practicum involved five kindergarten, one pre-first, and seven first-grade classrooms consisting of children 5 to 7 years of age. Each room accommodated 25 to 30 students. Students were enrolled for full six-hour days in classrooms which were arranged in simple, colorful, visually and sensually appealing environments which promote social interaction and cooperative learning. Professionals in charge of these primary classrooms who were participants in this practicum include two kindergarten, one pre-first, and seven first-grade teachers with Bachelor's Degrees as well as three kindergarten teachers with Master's Degrees. Table 1 shows the daily kindergarten, pre-first, and first-grade schedules and routines.

The morning began with songs, calendar activities, movement activities, student sharing, and storybook reading. However, reading, mathematics, and science workbooks were county and school mandated activities which were also part of the kindergarten and first grade's whole group schedule. After these academic

Table 1

Kindergarten, Pre-First, and First-Grade Schedule

Monday	Tuesday	Wednesday	Thursday	Friday

8:00-8:15 Opening Exercises (Attendance, Lunch Count, Pledge)

8:15-9:00
Pre-First and First Grade: Phonics and Language Arts

Kindergarten:
8:15-8:45 Special Classes: (A) Science/Computers, (B) Library/Art, (C) Physical Education, (D) Music
8:45-9:00 (Calendar, Discussions/Sharing)

9:00-10:00 Instructional Units
Kindergarten: Reading Readiness, Math, Science, Handwriting
Pre-First: Calendar Activities and Math Lessons
First Grade: Reading

10:00-11:00
First Grade: Handwriting
Kindergarten and Pre-First: Learning Centers (independent manipulative learning activities)
Housekeeping, Blocks, Language, Listening, Math, Art

10:30-11:00 Kindergarten Snack Time
Pre-First Lunch Time - Teacher M

11:00-12:00
Kindergarten:
11:00-11:20 Rest Time
11:20-12:00 Unit Concepts (Manipulative/Art Activities)
Cut and Paste

Pre-First:
11:00-11:30 Playground
11:30-12:00 Special classes

First Grade: Cafeteria (Lunch)

11:21-11:51 Teacher F	11:09-11:39 Teacher J
11:18-11:48 Teacher G	11:15-11:45 Teacher K
11:12-11:42 Teacher H	11:24-11:54 Teacher L
11:27-11:57 Teacher I	

(table continues)

12:00-2:00 - Kindergarten:

12:00-12:04	Clean-Up	
12:04-12:42	Cafeteria (Lunch) -	Teacher A: 12:04-12:34
		Teacher B: 12:06-12:36
		Teacher C: 12:08-12:38
		Teacher D: 12:10-12:40
		Teacher E: 12:12-12:42
12:42-1:30	Free Play - Playground/Free choice of manipulative centers.	
1:30-2:00	Closing Exercises and Dismissal	

12:00-2:00 - Pre-First:

12:00-12:30	Snack Time
12:30- 1:00	Story Time
1:00- 2:00	Interest Centers

12:00-2:00 - First Grade:

12:00-12:30	Special Classes: (A) Science/Computers, (B) Library, (c) Physical Education, (D) Music
12:30- 1:30	Mathematics and Sciences
1:30- 2:00	Closing Exercises and Dismissal

---

workbooks were completed, kindergarten children were encouraged to explore manipulative activities throughout the activity centers. The centers included: housekeeping materials, blocks, computer games, language games, mathematics games, clay, puzzles, etc. The morning schedule ended with snack and rest time.

The kindergarten afternoon schedule included storybook, reading, sharing, lunch, and playground time while pre-first and first graders participated in mathematics and science lessons. After school, teachers accompanied students outside and came into contact with awaiting parents. Thus, parents and teachers communicated either before or after school as needed

regarding students' progress. Students who did not go home after school, went to after-school day care service.

In conclusion, the school offered a wide variety of programs during and after school hours which serviced the needs of the community. Thus an environment of cooperation and support was established among faculty, parents, and students.

The writer is a kindergarten teacher who is certified in Early Childhood and Elementary Education. The writer has also worked in the school system for six years as a kindergarten teacher and holds a Master's Degree in Early Childhood Education. The primary responsibility of the writer is to teach kindergarten readiness skills and determine through observations and testing whether students are academically and developmentally ready at the end of the school year to proceed on to first grade level.

The writer has both background experience and schooling in mathematics education. Background experience consists of membership on the school's Southern Association of Colleges Self-Study's (S.A.C.S.) Mathematics Committee. Also, the writer has taken upper level mathematics courses prior to earning a teaching degree. All in all, the writer is a concerned educator of young children who possesses knowledge of abstract upper level mathematics.

CHAPTER II

STUDY OF THE PROBLEM

Problem Description

The present kindergarten mathematics curriculum does not promote nor develop problem solving and critical thinking skills. Examination of the kindergarten mathematics curriculum revealed specific details of the problem. To begin with, the school's Southern Association of Colleges 5-Year Self-Study (S.A.C.S.) indicated the need for the school to promote and develop problem solving and critical thinking skills in the curriculum. Kindergarten teachers interviewed supported the need for a more challenging mathematics curriculum. Moreover, observations of kindergarten classrooms revealed that the mathematics curriculum was taught predominantly through workbooks and rote memorization. Teacher surveys (Table 2) also indicated that Kindergarten Mathematics Minimum Basic Skills did not promote problem solving. Thus, students were unchallenged while teachers were dissatisfied with the present kindergarten math curriculum.

Furthermore, parents and other faculty members of the school revealed their dissatisfaction with the present school's primary mathematics curriculum. Parent interviews indicated that the school's primary focus was

on reading and language skills, without much regard to mathematics skills. Parents of young children who were less verbally adept expressed their concerns of unfair evaluations of their children. These unfair evaluations often continued into upper grade levels along with reading based, language biased curriculums.

The school's faculty members were also concerned with the present mathematics curriculum. Teacher questionnaires revealed (Table 2) that manipulatives were lacking for mathematics. Manipulatives are essential tools in visualizing mathematics concepts. The absence of these materials can be detrimental. An interview with the teacher of learning disabilities revealed that the mathematics curriculum did not focus on problem-solving skills nor on understanding the practical significance of mathematics.

Rote memorization and drilling not only did not challenge students but denied students understanding of the significance or meanings of mathematical functions necessary for practical applications. The understanding of mathematical concepts, essential in problem solving, needed to be developed during students' early years if students were to succeed in mathematics during their later years. Briefly stated, the problem was that kindergarten

students needed to develop problem-solving skills in mathematics.

Problem Documentation

Several sources revealed that kindergarten students did not develop mathematics problem-solving skills. To begin with, the S.A.C.S. report listed problem solving and critical thinking skills as one of the school's primary goals. The S.A.C.S. report also revealed that manipulative materials, better organization, and more effective evaluative measures were needed in the present mathematics curriculum. This unchallenging view of the school's mathematics curriculum was further revealed by interviews with teachers, faculty, and parents.

In addition, faculty questionnaires, as documented on Table 2, showed that reading and language skills took priority over mathematics skills in elementary education. Students' Individual Instructional Plan (I.I.P.) folders and cumulative records also showed that kindergarten students were evaluated by their verbal skills without much regard to mathematics skills.

Interviews with teachers, faculty, and parents indicated their sentiments of an unchallenging mathematics curriculum. Observations of kindergarten classrooms revealed excessive drilling and memorization

of facts. Mathematics lessons lacked problem solving activities which may add interest and enliven the mathematics curriculum.

Table 2

Early Childhood Faculty Questionnaire Results

Question	Yes	No
1. Do you feel that reading and language skills take priority over mathematics skills in kindergarten education?	7	1
2. Is the present mathematics curriculum in kindergarten challenging and interesting?	2	6
3. Does the present mathematics curriculum develop problem solving and critical thinking skills in young children?	1	7
4. Do you feel that young children can master mathematical skills that involve higher cognitive thinking skills?	6	2
5. Would you like to see more manipulatives and group learning in the mathematics curriculum?	8	0
6. Is the present mathematics curriculum too workbook oriented?	6	2
7. Should children be evaluated by their mathematical skills equally as their verbal skills?	8	0
8. At present, are mathematical skills evaluated equally as verbal skills?	0	8

Likewise, teacher questionnaires, shown on Table 3, revealed the lack of manipulatives provided by the school, inhibiting the effective teaching of mathematics. Thus, as revealed by anecdotal observations, kindergarten students were provided workbooks, increasing paper-pencil activities in mathematics and reducing active participation.

Table 3

Teacher Questionnaire Results

Question	Yes	No
1. Do you feel that the Kindergarten Minimum Basic Mathematics Skills involve problem solving skills?	1	3
2. Do you feel that the present kindergarten mathematics curriculum is too workbook oriented?	3	1
3. Are reading and language skills a predominant part of the kindergarten curriculum?	3	1
4. Do we need more hands on, manipulative activities involving problem solving in mathematics?	3	1
5. Is the present mathematics curriculum in kindergarten challenging and interesting to your students?	1	3
6. Do you use manipulatives in your mathematics activities for problem solving and deductive reasoning lessons?	2	2

(table continues)

Question	Yes	No
7. In the present mathematics curriculum, do your students participate in group problem solving and brainstorming activities?	1	3
8. Do you know some causes of mathematics anxiety?	4	0
9. Would you like to make kindergarten mathematics more interesting and exciting?	4	0
10. Do you feel comfortable teaching higher level mathematics using innovative approaches?	1	3

Causative Analysis

Teacher attitudes toward the mathematics curriculum were important elements in developing successful programs. As educators and communicators, teachers influence the attitudes and perceptions of others with their teaching styles and philosophical outlooks. However, teachers' attitudes, as revealed by the questionnaire results of Table 2, indicated that verbal skills, such as reading and writing were more important skills for children to master than mathematic skills. Thus, the school's curriculum focused heavily on reading and language achievement.

Moreover, parents and teachers thought that problem-solving skills were too difficult to teach in primary grades. Because problem-solving skills were seldom

evaluated or developed in primary grades, parents did not encourage their children to develop problem-solving skills in mathematics. The lack of interest in teaching problem-solving skills in primary grades led to the lack of understanding of cognitive development in mathematics. Thus, parents and teachers were unaware of the causes of mathematics avoidance and anxiety which occurred in their children's later years.

Likewise, teachers were unaware of innovative approaches in mathematics. They were primarily more comfortable using traditional teaching methods than trying newer approaches. Thus, students were expected to be receptive learners and often discouraged from interaction and exploration during mathematics lessons.

Furthermore, kindergarten teachers were unable to teach mathematics effectively within the Piagetian concrete preoperational framework due to lack of developmentally appropriate materials. Manipulatives, for example, were lacking in the mathematics curriculum causing teachers to focus more on workbook activities and rote memorization to achieve academic achievement. Manipulative materials, when properly introduced, encouraged participation in young children and developed problem-solving skills.

Relationship of the Problem to the Literature

Successful mathematics education involved teaching beyond the basics. Toffler (1980) suggested that the technological age was quickly taking over the industrial age. The arrival of the technological age brought with it the "information age" (Chance, 1986, p. 2). Therefore, students needed to learn higher level thinking and problem solving skills involved in information collecting (Chance, 1986).

Mitchell (1990) implied that high school graduates were not well prepared to participate in business or technology because they were not taught essential mathematical concepts which were necessary to function in today's work force. Mitchell claimed that the neglected concepts in mathematics were: statistics, probability, algebra, word problems, measurement, and geometry. Although the formal studies of mathematics occurred in middle grades and high schools, the development of mathematic foundations needed to take place in the beginning of the educational process (Mitchell, 1990). Bitter, Hatfield, and Edwards (1989) felt that students who were successful in mathematics problem solving were those who had earlier experience with problem solving and

critical thinking skills. Therefore, it is the responsibility of all educators to provide effective learning strategies that will enhance students' mathematical cognition, from early childhood through later adulthood.

Several approaches to problem solving needed to be considered and examined critically. First of all, Ernest (1989) believed that teaching mathematics in the traditional way, which only involved whole class rote learning, did not effectively teach mathematical concepts nor promote higher level thinking skills. Cornelius (1982) also supported the need for teachers to use innovative teaching methods and incorporate modern technological changes into their curriculum. However, participation and experience must be predominant aspects of the mathematics curriculum. Student participation was lacking due to the monotony of teaching mathematics as unrelated facts (Hazelwood, Stouffer, & Warshauer, 1989). Without participation and experience, students could not develop problem-solving skills. Students who did not gain problem solving experience developed mathematics avoidance, which in turn resulted in mathematics anxiety (Bitter, Hatfield, & Edwards, 1989). Thus, unexperienced

students were most likely to underestimate their mathematical abilities (Cocking & Mestre, 1988).

Developmental Approaches to Problem Solving

Resnick and Ford (1981) believed that young children were able to grasp problem-solving skills if they were presented with age-appropriate familiar elements. Furthermore, young children between the ages of 5 and 6 were at Piaget's preoperational stage and needed concrete objects or manipulatives as well as pictorial representation to comprehend abstract concepts (Jencks & Peck, 1987). Skolnick (1986) described Benjamin Bloom's argument that children's "intellectual development takes place in the preschool years" and "becomes hard to change later" (p. 346). Young children needed to develop confidence in their ability to perform mathematical skills. Confidence could only be developed by allowing young children to work independently and "at their own rate" (Skolnick, Langfort, & Day, 1982, p. 54).

Lesh, Landau, and Hamilton (1980) described five methods of mathematical presentations: real-world situations, manipulative models, pictorial representations, spoken symbols, and written symbols. Thompson (1989) believed that real-world experiences added meaning and allowed children to be effective

problem solvers. For example, children would become active participants in mathematics if geometrical shapes and sizes were related to their environment (Zaslavsky, 1989). Resnick and Ford (1981) added that manipulatives were also important and developmentally appropriate for young children in visualizing abstract mathematical concepts. Manipulatives also provided motivation and interest that encouraged participation (Bohning & Radencich, 1989). Moreover, pictorial representations united concrete materials with abstract concepts aiding in the understanding of higher level skills (Jencks & Peck, 1987).

Lastly, young children's counting skills were important prerequisites to later development of mathematics skills. Baroody (1989) suggested that students explore real-life situations and later work with symbolic representations and higher level thinking.

DeBono (1984) expressed that thinking skills involve both the development of analytical (logical) and perceptual thinking. DeBono also believed that good thinkers could be developed. McPeck (1981) described DeBono's methods of lateral or perceptual thinking as creative and supplementary to vertical thinking. DeBono's method of lateral thinking taught "operacy" (doing) as well as critical thinking skills (DeBono,

1985b, p. 73). The elements of lateral thinking include: operating skill, intelligence, and experience. Thinking should have a specific purpose and requires discipline. DeBono (1985b) described "effective thinkers" as people who have clear goals, not wandering minds. DeBono (1985b) also stated that "basic thinking skills are fundamental enough to cut across age, ability, and cultures" (p. 7). DeBono (1985a) described the process of thinking as similar to putting on a "thinking hat" (p. 11). Different types of thinking were like wearing different types of hats. Thinking was a conscious act (DeBono, 1985a). Therefore, good "habits of the mind" and attention directing tools that are developed in early childhood could bring out intelligence (DeBono, 1985b, p. 2).

Suzuki (1981) based his approach on the ability of all children to perform higher level thinking. He suggested that children who did not grasp concepts were not at fault. The ways of teaching should be analyzed to accommodate for the needs of these children (Suzuki, 1981).

Hazelwood, Stouffer, & Warshauer (1989) also believed that young children were capable of high achievement if they were taught the relationships and significance of mathematical functions. Problem

solving should be made exciting and enjoyable because "monotony is our worst enemy" (Hazelwood, Stouffer, & Warshauer, 1989, p. 9). Students should have positive attitudes towards mathematics if they were to succeed in problem solving (Schmalz, 1989). Therefore, if mathematical concepts could be translated into meaningful terms, students could develop better understanding of mathematical relationships.

Hazelwood, Stouffer, and Warshauer (1989) suggested that Suzuki's belief that young children were capable of higher level thinking should be combined with Polya's approach that problem solving involved understanding of the mathematical language through comprehension of operational functions. Thus, by combining these approaches, enjoyable and interesting methods of teaching mathematics to young children could be developed.

Teaching Strategies for Problem Solving

Technological advancements cause the need for educators to present deductive reasoning and problem solving strategies rather than simple knowledge of computations (Cemen, 1989). However, teachers often "teach the way they were taught" and ignore innovative approaches to teaching mathematics (Cornelius, 1982, p. 30). Innovative approaches are necessary to comprehend technological advancements.

Teachers needed to alter their teaching styles in such a way that would encourage active classroom involvement. Teaching mathematics in the traditional method of whole class instruction and board work lessened individualization of the curriculum (Ernest, 1989). Mathematics was also often taught as a series of unrelated facts through memorization and drilling (Strickland & Denitto, 1989). Elkind (1988) suggested that teachers also needed to be trained to use manipulative materials appropriately as problem-solving tools. Through research, evaluation, and collaboration of ideas, teachers can learn effective and innovative approaches of problem solving (Pateman, 1989).

Positive attitudes and self-concepts towards mathematical problem solving also needed to be developed. Confidence in one's ability to perform cognitively was important because complex mathematics required risk-taking as well as application of skills (Skolnick, Langhort, & Day, 1982). Mayher (1990) theorized that children's mathematical performance is hindered when they have unrealistic expectations, resulting in emotions that reduce problem solving capacity.

Also, people often underestimated their mathematical abilities (Cocking & Mestre, 1988). Kelley and Tomhave

(1985) discovered that even elementary educators showed signs of mathematics avoidance and anxiety which was transferred to their students. Teachers needed to provide educational environments which allowed students to express ideas without taking personal risks (Paul, 1984). Also, a child's sense of wonder needs attentive nurturing (Paul, 1984).

Frase (1990) expressed the need for children to transfer knowledge from concrete to abstract forms. This abstract knowledge could be obtained through several methods. Encouraging children to interact in small groups during mathematical discussions was an alternative to traditional teaching methods that was often overlooked by elementary educators (Zaslavsky, 1989).

Everyday situations could also encourage mathematics activities (Kamii, 1982). Problem-solving skills could be presented to young children using "familiar elements" (Resnick & Ford, 1981, p. 194). For example, the concept of quantity could easily be taught because it occurred in the everyday life of infants (Mestre, 1988). Children also needed hands-on materials to enhance their "natural ability to learn" (McCracken, 1987, p. 2). These early learning experiences resulted in school success because mathematics anxiety was reduced (Bitter, Hatfield, & Edwards, 1989). In conclusion, mathematics teaching

strategies needed to add interest and excitement as well as practical experiences if students were to be motivated to learn and retain their knowledge.

CHAPTER III

ANTICIPATED OUTCOMES AND EVALUATION INSTRUMENTS

Goals and Expectations

The goal of this practicum was that young children would have problem-solving skills. This practicum would result in students showing their mathematics problem-solving abilities through their expertise and active participation in interactive learning, brainstorming, deductive reasoning, cooperative learning, and explorative lesson activities. Thus, students would become active initiators of their educational setting.

Students would also develop their mathematics problem-solving skills through knowledge of problem-solving strategies and appropriate uses of concrete manipulatives. They would demonstrate their knowledge of problem solving through manipulation of their environment and oral communication of solution strategies. Overall, the practicum involved a goal that would enhance creativity, congeniality, and productivity.

Behavioral Objectives

The behavioral objectives would reflect advancements in both social-communicative and cognitive aspects of mathematics problem solving. Specific objectives

involving students' cognitive advancements include the following:

1. Students would improve problem-solving abilities.

2. Students would improve deductive reasoning, critical thinking, and problem-solving skills.

Objectives would also show social-communicative improvements.

1. Students would become more interactive during mathematics lessons.

2. Teachers and early childhood faculty would react positively to problem-solving activities in mathematics.

3. Teachers would become more effective initiators of problem solving.

4. Teachers and parents would be able to use take-home manipulatives as problem-solving tools.

Measurement of Objectives

The behavioral objectives were to be measured in several ways. First of all, cognitive achievements were to be measured through pre/posttesting, observations, and checklists.

1. Seventy percent of the targeted population would increase scores by 15 points from pretest to posttest of the Test of Nonverbal Intelligence (TONI).

2. Students would demonstrate a 50% increase on an observational checklist that measures occurrences of activities displaying knowledge of deductive reasoning, critical thinking, and problem-solving skills.

Secondly, social-communicative skills of mathematics problem solving were to be measured through comparisons of sociograms, observations, questionnaires, interviews, checklists, lesson plans, and parent/teacher conference forms.

1. Comparisons of sociograms would reveal 50% increased interactions during mathematics lessons.

2. Examination of pre- and post-observational checklists and questionnaires would reveal a 50% increase in positive responses.

3. Lesson plans and observations would reveal teachers' increased mastery in teaching problem-solving strategies as measured by 50% positive answers on a writer-constructed checklist.

4. Conference forms would reveal collaborative efforts in using manipulatives in problem solving as measured by 50% increase on a checklist showing students' ability to depict mathematical meanings through manipulatives.

In summary, Table 4 shows the measurements and standards that were to be used in this practicum to indicate achievements in mathematics problem-solving skills.

Table 4

Measurements and Standards of Achievement
in Mathematics Problem Solving Skills

The End Result	Evaluation Tool	Standard of Achievement
1. Students would improve problem-solving abilities	TONI (Test of Nonverbal Intelligence)	70% of the targeted population would increase scores by 15 points from pretest to posttest
2. Students would become more interactive during mathematics lessons.	Sociograms (Appendix A)	Comparisons of sociograms would reveal 50% increased interactions during mathematics lessons.
3. Students would improve deductive reasoning, critical thinking, and problem-solving skills.	Observations & Checklists (Appendix B)	Students would demonstrate 50% increase on observation checklist that measured occurrences of activities displaying knowledge of deductive reasoning, critical thinking, and problem-solving skills.
4. Teachers and early childhood faculty would react positively to problem-solving activities in mathematics.	Observations (Appendix C), Interviews (Appendix D), & Questionnaires (Appendix E)	Examination of pre- and post-observations checklists and questionnaires would reveal 50% increase in positive or "yes" responses.
5. Teachers would would become more effective initiators of problem solving.	Lesson Plans Observations & Checklists (Appendix F)	Lesson plans and observations reveal teachers' increased mastery in teaching problem-solving strategies as measured by 50% positive or "yes" answers on writer-constructed checklist.
6. Teachers and parents would be able to use take-home manipulatives as problem-solving tools.	Parent/Teacher Conference Forms & Checklists (Appendix G)	Conference forms would reveal collaborative efforts in using manipulatives in problem solving as measured by 50% increase on checklist showing teachers' and parents' enhanced knowledge, understanding, and abilities in using manipulatives as problem-solving tools.

Mechanisms for Recording Unexpected Events

Teachers were to keep logs and journals in order to document bimonthly class routines and record unusual events. Analysis of these documents would allow the writer to develop alternative plans as needed. Also, teacher interviews and observations were to be conducted monthly to determine if unexpected events occurred which required changes in implementation. Lastly, teachers would conduct anecdotal observations monthly and reported any unusual events or behaviors that needed immediate attention and modification to the writer. In summary, student and teacher behaviors would be carefully observed in order to determine if unexpected events needed alternative plans.

Description of Plans for Analyzing Results

Careful comparison of data before and after implementation was of utmost importance. Therefore, anecdotal observations, observational checklists, sociograms, questionnaires, interviews, and test results were to be carefully documented throughout implementation. Sociograms for each classroom would be tabulated to determine interactions/popularity of students during mathematics lessons before and after implementation of this practicum.

The results of pre/posttest TONI would be recorded for each classroom and tabulated. The TONI was selected because it measured problem solving abilities among students efficiently according to age group. A histogram graph would be used to visualize the accomplishment of problem-solving skills after practicum implementation. In conclusion, descriptive statistics would be utilized to analyze resulting data.

CHAPTER IV

SOLUTION STRATEGY

Discussion and Evaluation of Solutions

Teaching styles had progressed to using innovative techniques which differed from traditional methods. Educators needed to communicate and share mathematics teaching strategies which were successful in the classrooms. Pateman (1989) considered collaborative teaching important in mathematical instruction because teachers learned from observing each other.

Educators had learned various strategies which proved successful in research studies. To begin with, young children were shown to gain security in their mathematical abilities when they were allowed to explore solutions independently and at their own pace (Skolnick, 1982). Moreover, children learned mathematical meanings through their significance in the real world (Thompson, 1989). Therefore, children learned best through interaction and manipulation of their environments. Zaslavsky (1987) stated that students needed to participate in small group discussions and interact with other students in order to become effective problem solvers. Also, manipulatives and pictorial representations were significant modes of presentation in mathematics education (Lesh, Landau, & Hamilton, 1980).

However, teachers needed to realize the importance in directing students' attention to perceptual and analytical skills (Chance, 1986). Teachers also needed to be trained to use manipulatives as more effective tools of problem solving (Elkind, 1988). Once educators understood the significance of proper introduction to mathematics, higher level skills would have more stable foundations. For example, rational counting was an important activity for early mathematics because it led to more complex, higher level cognitive skills (Frank, 1989). Therefore, the preliminary basic concepts of mathematics were important skills to master if higher level concepts were to be developed.

Examinations of the discussed solutions indicated that teachers needed to alter and expand their mathematical teaching strategies to include problem-solving activities. Young children understood concepts through concrete terms. Likewise, kindergarten students were able to comprehend abstract mathematical concepts through the use of everyday objects (Bennett, 1986). Developing mathematical concepts through play and manipulation of their environments was also effective and developmentally appropriate for young children (Maxim, 1989).

Incorporating question and discussion sessions as well as utilizing real life experiences in mathematics

teaching were the foundations of symbolic thinking skills (Baroody, 1989). When teachers developed questioning skills that encouraged interpretive discussions, higher level of thinking was explored (Falkof & Moss, 1984). Also, positive learning experiences resulted from classrooms which presented interactive environments (Sadker & Sadker, 1985). Furthermore, discovering manipulatives through exploration and discussions developed a curiosity for mathematics that was essential for successful developments of mathematical skills in later years (Henniger, 1987).

However, teachers who were trained to present manipulatives appropriately would be more effective at teaching higher level skills (Elkind, 1988). Manipulatives and visuals should be presented in a nondemonstrative way so that students could collaborate possible methods and solutions on their own and thus develop problem-solving strategies (Ross, 1989). Furthermore, discussions and question activities added excitement to the mathematics curriculum as well as provided opportunities to experience and practice problem solving (Easterday and Clothiaux, 1985). In summary, an approach to problem solving should be developed that combine effective lessons, cooperative learning, and independent exploration of manipulative materials.

Description of Selected Solution

The writer developed a mathematical program which involved learning through interaction, manipulation, and collaboration of teaching strategies. Student interactions included group discussions, interest center activities, brainstorming activities, deductive, and reasoning activities. Manipulation involved cut and paste activities, manipulative games, illustrations, and charting activities. Collaboration of teaching strategies encouraged teachers to share ideas that enhanced problem-solving activities through proper use of manipulatives and pictorial presentation, as well as informing teachers of effective mathematics teaching. The writer believed that these approaches would work because they utilized developmentally appropriate activities for problem solving and encouraged teachers to try new ideas.

The steps taken in this practicum began with pretesting of students' problem-solving abilities, continued with implementation and observations, and ended with posttesting of problem-solving abilities of the targeted population. Teachers involved collaborated and discussed problem-solving strategies that were presented in their classrooms. Weekly lesson plans were provided to teachers of the targeted population.

Concerns were discussed and lessons were explained in detail.

Throughout the eight months of practicum implementation, students explored different mathematical concepts which promoted various levels of thinking. Observations, teacher observational checklists (Appendix C), student observational checklists (Appendix B), teacher interview checklists (Appendix D), conference form checklists (Appendix G), lesson plan checklists (Appendix F), interviews, logs, sociograms (Appendix A), and questionnaires (Appendix E) were conducted before, during (monthly), and after implementation. Lastly, posttesting measured the progress achieved as a result of practicum implementation. All in all, a combination of various successful studies were utilized to accommodate the classroom population, students' age group, and practicum time frame.

Report of Action Taken

The implementation process of this practicum primarily followed the procedures proposed. Overall, the time line and activities proceeded as planned. Furthermore, the cooperation and dedication of all participants involved contributed to this practicum's effectiveness and productivity.

The implementation process began with the introduction of manipulatives and group discussions during mathematics lessons. At first, students were uncooperative and competitive. For example, students would often argue about who had correct answers and did not listen to the point of view of others. However, students soon began to interact positively as their teachers encouraged brainstorming activities and differing points of view. Thus, students worked in teams and interacted productively as they became more cooperative, attentive, and collaborative. The mathematical themes implemented included: numbers, sets, geometry, time, monetary values, measurement, operations, and logical thinking.

The number of participants involved and specific data gathering schedules varied slightly due to the inception time of this practicum. To begin with, practicum implementation began mid-year at the school as opposed to the beginning of the school year as anticipated. Pre-first and first grade teachers became additional participants to the initial kindergarten teachers involved. All of the original students continued participation during the summer either by attending summer school or completing a take-home packet of mathematics activities which contained the lessons

taught during the summer. All parents of student participants were contacted and assisted their children with mathematics activities, following specific instructions for lessons. Thus, 111 of the original 145 students attended summer school, 4 students transferred out of the school, and the 30 remaining students completed their take-home mathematics packets.

Moreover, data gathering schedules which involved teacher and student observations were adjusted to school schedules. Various times which involved data gathering, for instance, were altered due to holidays and unanticipated school events which prevented the writer from collecting information effectively and efficiently.

In conclusion, the action taken during practicum implementation varied slightly due to schedule conflicts and unanticipated events. For the most part, however, the practicum proceeded on schedule as planned. Activities also followed the anticipated calendar plans. Moreover, the congenial attitudes and collaborative efforts of the additional and original teachers involved contributed to a successful transition process and allowed for uninterrupted routines in practicum applications.

CHAPTER V

RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

Results

As indicated by anecdotal observations, interviews, sociograms, and testing of problem-solving abilities; the results of this practicum revealed that students improved their cognitive and social-interactive skills during mathematics lessons. Furthermore, teachers and parents became effective and knowledgeable educators of mathematics problem solving.

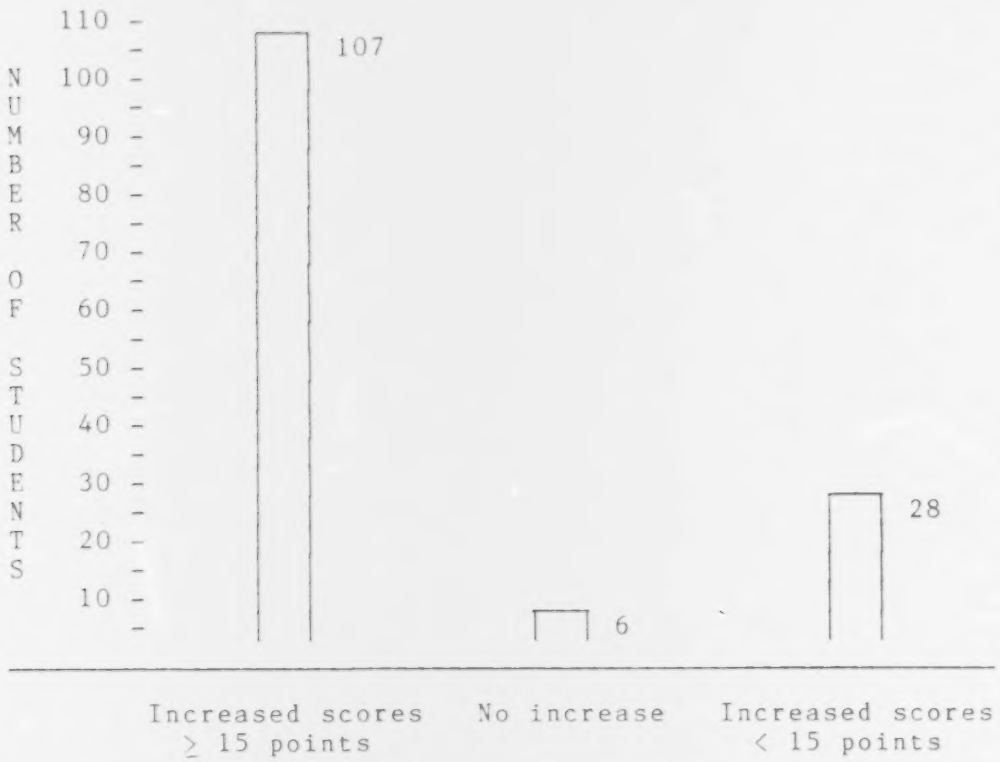
A comparison of the practicum objectives with actual outcomes show the positive results of this practicum. To begin with, the first objective was that 70% of the targeted population would increase TONI scores by 15 points from pretests to posttests. The results were that 77% of the targeted population showed this improvement.

Table 5 shows the actual number of 107 students who accomplished the objective as opposed to the 34 students who did not meet the objective (6 students whose scores did not change and 28 students whose increased scores were below 15 points).

Secondly, sociogram (Appendix A) comparisons were to show 50% increased interactions. However, data reveals only a 45% increase in interactions. Table 6 shows an

Table 5

Pre/Posttest Comparison of the
Test of Nonverbal Intelligence (TONI)



increase in the beginning interaction rate of 55% at the fourth week to 100% at the 32nd week of implementation. Moreover, the data implies a gradual decrease in inactivity and increase in activity between week 4 and week 32. Observations also revealed increases in students initiating verbal and physical contact during mathematics lessons.

Table 6

Sociograms of Student Interactions
During Mathematics Lessons

Week	Number of Student Inactive - Active	Total Number of Students	Interaction Rate
4	65	80	145	55%
8	16	129	145	89%
12	3	142	145	98%
14	0	144	144	100%
20	0	92	92	100%
23	0	92	92	100%
28	0	141	141	100%
32	0	141	141	100%

Thirdly, student observations were to demonstrate a 50% increase in deductive reasoning, critical thinking, and problem-solving skills. Table 7 reveals a 75% improvement on such skills. These skills were observed through group activities as well as individual student actions.

Fourth, teacher observations (Appendix C), interviews (Appendix D), and questionnaires (Appendix E) were to reveal a 50% improvement in positive attitudes toward mathematics problem solving. The data indicates a 100% increase in positive attitudes as revealed by teacher observations (Table 8) and questionnaires (Tables 9 and 10). Teacher interviews revealed a 90% increase in positive attitudes (Table 11).

Table 7

Student Observational Checklist Class Results

Student Activities	Class Responses Week 4 Yes	No	Week 32 Yes	No
Students interact with each other during mathematics lessons.	2	3	8	0
Students use manipulatives to solve mathematics problems.	0	5	8	0
Students participate in group problem-solving activities.	0	5	8	0
Students offer teacher alternative solutions to mathematics problems.	0	5	8	0
Students work independently to solve problems.	5	0	2	6
Students' performance indicate deductive reasoning abilities.	0	5	8	0
Students ask questions freely during mathematics lessons.	0	5	8	0
Students cooperate efficiently and effectively to solve mathematical problems.	0	5	8	0
Students show abilities to relate mathematical functions to everyday situations and practical applications.	0	5	8	0
Students demonstrate understanding of mathematical functions and symbols.	0	5	8	0
Students show abilities to think critically.	0	5	8	0
Students show interest in exploring mathematical concepts.	5	0	8	0
Number of Positive Responses (Total Number of Questions = 12)	2		11	
Percent of Positive Responses	17%		92%	

Increase in Percent of Positive Responses = 75%

Note: More "Yes" responses indicate a "positive response."

Table 8

Teacher Observational Checklist Results

Teaching Strategies	Yes	No	Yes	No
Teacher introduces manipulatives to explain mathematics concepts.	0	5	8	0
Teacher encourages active participation during mathematics lessons.	0	5	8	0
Teacher uses effective questioning skills during mathematics problem-solving activities.	0	5	8	0
Teacher encourages freedom of students to explore their environments during mathematics lessons.	0	5	8	0
Teacher allows cooperative learning of students.	0	5	8	0
Teacher discusses meanings and practical applications of mathematical functions.	0	5	8	0
Teacher listens to student concerns and suggestions on mathematics lessons.	0	5	8	0
Teacher uses pictorial representations of abstract mathematical concepts.	2	3	8	0
Teacher explains abstract concepts through utilization of everyday situations and familiar objects.	0	5	8	0
Teacher encourages teamwork and group discussions during mathematics lessons.	0	5	8	0
Teacher uses attention direction tools to focus students' thinking.	0	5	8	0
Number of Positive Responses (Total Number of Questions = 11)	0		11	
Percent of Positive Responses	0%		100%	

Increase in Percent of Positive Responses = 100%

Note: More "Yes" responses indicate a "positive response."

Table 9

Teacher Questionnaire Results

Questions	Yes	No
1. Have you gained sufficient knowledge of problem solving and critical thinking strategies to effectively apply these strategies during your mathematics instructions?	13	0
2. Are you satisfied with the manipulatives provided during the implementation of this practicum on problem solving mathematics strategies?	13	0
3. Have your students become more involved in mathematics since implementation of this program?	13	0
4. Do you feel comfortable teaching higher level mathematics using innovative approaches?	13	0
5. Is the problem solving program implemented challenging for your students?	13	0
6. Do your students find problem solving interesting?	13	0
7. Are you satisfied using cooperative learning and questioning activities during mathematics lessons?	13	0
8. Do you like the new critical thinking approach to problem solving better than the approach you have been using?	13	0
9. Do parents react positively to teaching higher level mathematics skills using creative thinking skills?	12	1
10. Are you satisfied with the skills covered during implementation of this practicum?	13	0
Total Number of Positive Responses (Total Number of Questions = 10)	10	
Percent of Positive Responses	100%	

Note: More "Yes" responses indicate a "positive response."

Table 10

Early Childhood Faculty Questionnaire Results

Questions	Yes	No
1. Do you like the new critical thinking approach to mathematics problem solving?	9	0
2. Are teachers demonstrating effective teaching skills during mathematics lessons?	9	0
3. Do you prefer the new creative thinking approach to the previous workbook-oriented, drilling approach used by teachers?	9	0
4. Do students react positively to problem-solving strategies and cooperative learning?	9	0
5. Do you feel that students are grasping higher level thinking skills through the use of manipulatives and pictorial representations?	9	0
6. Do you feel that manipulatives are important for young children learning mathematics skills?	9	0
7. Are you comfortable assisting teachers in problem solving activities?	9	0
8. Are parents reacting positively to this program in mathematics problem solving through explorative learning?	9	0
9. Would your children benefit from this program?	9	0
10. Would you like to learn more about problem-solving skills and critical thinking strategies in mathematics?	9	0
Total Number of Positive Responses (Total Number of Questions = 10)	10	
Percent of Positive Responses	100%	

Note: More "Yes" responses indicate a "positive response."

Table 11

Teacher Interview Checklist Results

Teacher Attitudes and Observations	Week 1 Yes	Week 1 No	Week 29 Yes	Week 29 No
Teacher reveals collaborative efforts with fellow teachers on innovative mathematical approaches.	2	3	8	0
Teacher shows satisfaction with practicum implementation procedures.	4	1	8	0
Teacher expresses enthusiasm in learning new approaches to mathematical problem solving.	2	3	8	0
Teacher notices improvement in students' mathematics abilities.	2	3	8	0
Teacher observes parental support and enthusiasm with innovative teaching techniques in mathematics.	0	5	6	2
Teacher shows familiarity with innovative teaching techniques in mathematics.	0	5	8	0
Teacher expresses improvement of mathematics curriculum.	2	3	8	0
Teacher notices improvements in students' interest in mathematical functions.	2	3	8	0
Teacher notices improved classroom participation during mathematics lessons.	2	3	8	0
Teacher indicates ease in using innovative strategies to teach higher level mathematics.	2	3	8	0
Total Number of Positive Responses (Total Number of Questions = 10)	1		10	
Percent of Positive Responses	10%		100%	

Increase in Percent of Positive Responses = 90%

Note: More "Yes" responses indicate a "positive response."

Furthermore, lesson plan checklists (Appendix F) were to show a 50% increase in positive answers which indicate mastery and organization of presenting problem-solving strategies (Table 12). The data shows a 90% improvement in presentation methods and strategies. Teachers were observed to keep concise and goal-directed plans after practicum implementation as opposed to vague, nondirective plans prior to implementation.

Lastly, conference checklists (Appendix G) were to indicate a 50% increase in cooperative parent/teacher efforts to educate students in math problem solving. However, no increases were measured since both checklists for weeks 13 and 32 indicated a 100% collaboration (Table 13). Thus, the initial data (week 13) showed no need for improvement in this area and no decline in positive answers was observed on week 32.

In conclusion, results were positive and exceeded anticipated outcomes. Moreover, attrition rate was low since only four students out of the total population of 145 students ceased participation during praticum implementation. Thus, continuity and stability were established and allowed for accurate data collecting.

Conclusion

Results of this practicum revealed both behavioral and cognitive progress. To begin with, behavioral

Table 12

Lesson Plans Checklist Results

Observation of Content	Week 1 Yes	Week 1 No	Week 29 Yes	Week 29 No
Plans indicate clear and concise strategies for mathematics lessons.	0	5	8	0
Plans show organized and focused questioning strategies for mathematics lessons.	0	5	8	0
Plans indicate equal mathematics activities as reading and language activities.	2	3	8	0
Plans reveal group projects and cooperative learning strategies during mathematics activities.	0	5	8	0
Plans are easy to follow regarding attention directing techniques of critical thinking.	0	5	8	0
Plans show clear objectives of mathematics lessons.	5	0	8	0
Plans show more explorative learning than workbook activities during mathematics lessons.	2	3	8	0
Plans show manipulative activities and pictorial representations involving higher level mathematical concepts.	0	5	8	0
Plans emphasize problem-solving lessons during mathematics.	0	5	8	0
Plans have clear time limitations and directed goals for mathematics problem-solving activities.	0	5	8	0
Total Number of Positive Responses (Total Number of Questions = 10)	1		10	
Percent of Positive Responses	10 %		100%	

Note: More "Yes" responses indicate a "positive response."

Table 13

Conference Form Checklist Results

Observations	Week 13 Yes	Week 13 No	Week 32 Yes	Week 32 No
Parents and teachers discuss the importance of mathematics problem solving.	5	0	6	2
Parents and teachers discuss the importance of critical thinking skills in mathematics.	5	0	5	3
Students show improved mathematical skills.	5	0	8	0
Reading and mathematical skills are discussed as equal in importance.	5	0	8	0
Conference forms reveal collaborative efforts of teachers and parents in teaching students mathematical problem-solving skills.	3	2	6	2
Goals for the mathematics curriculum are discussed between parents and teachers.	5	0	8	0
Observations of mathematical involvement during mathematics lessons are included in behavioral objectives.	5	0	8	0
Mathematical progress is reported along with reading progress.	5	0	8	0
Parents and teachers discussed mathematical strategies.	5	0	6	2
Parents and teachers reveal positive attitudes in the mathematical curriculum.	5	0	8	0
Number of Positive Responses (Total Number of Questions = 10)	10		10	
Percent of Positive Responses	100%		100%	

Note: More "Yes" responses indicate a "positive response."

objectives were achieved through increased participation and interaction as revealed by sociograms, student and teacher observational instruments, and anecdotal observations. These observational instruments revealed that students as well as teachers were hesitant and unenthusiastic at first about participating in group problem-solving activities. Student observations revealed that they were inexperienced group problem solvers. Students often displayed conflicts, competitiveness, and isolation when they first began group activities. However, they soon became cooperative, attentive, and interactive. Thereafter, the students grew more analytical, perceptive, and explorative as they gained knowledge and experience with group problem-solving techniques.

Similarly, teachers who were traditional, restrictive, not confident, and monotonous became unrestrictive, experimental, confident, and innovative in their problem-solving approaches. As revealed by teacher anecdotal observations, teachers had provided unchallenging mathematics lessons by restricting discussions, prohibiting student interactions, and reaching conclusions without explanations of processes. Teacher interviews also revealed their lack of knowledge and understanding of innovative approaches. For example,

teachers often requested demonstrations of suggested lesson activities due to their uncertainty of problem-solving approaches.

However, as teachers experimented with discussions and presentation techniques, they became more aware of the effectiveness of using attention directing tools (visual aides, manipulatives, pictorial representations, written symbols, etc.) and allowing explorations (discussions, interactions, real-world applications, etc.) in teaching mathematical concepts. These methods of presentation enhance and enliven mathematics lessons (Lesh, Landau, & Hamilton, 1980). Teachers learned how to build children's confidence in their problem-solving abilities. Confidence is essential in achieving mathematical problem-solving abilities. Allowing students to work independently and interactively is necessary in building confidence (Skolnick, Langfort, & Day, 1982).

Moreover, sociograms indicated only a 45% increase in student interactions. Further analysis of the data shows that the targeted population began with 55% participation and escalated to 100% participation. Therefore, only a 45% increase was possible.

Conference checklists also revealed that during weeks 13 and 32 conferences were 100% effective (as

indicated by 100% positive responses). Thus, this area did not show a need for improvement. Moreover, weeks 13 and 32 were the designated times of observation of conference materials. These dates were well into the practicum process. Teachers as well as parents had already acquired sufficient knowledge of problem-solving approaches by those designated observation times.

Cognitive progress was measured by the Test of Nonverbal Intelligence (TONI). Seventy-seven percent of the students improved scores by 15 points. Data analysis and student observations indicate that a majority of the students in this category began with very low scores. In other words, these students benefited most from this practicum since their low pretest scores suggest their need to learn more effective problem-solving techniques. Students who demonstrated average to high ability in problem solving showed some improvement, although not as significant as their lower ability counterparts.

Experience with problem-solving techniques may also contribute to the success of the individuals who initially scored lower. Lack of problem-solving skills often causes individuals to underestimate their abilities (Cocking & Mestre, 1988). A positive self-concept is needed to perform well cognitively (Skolnick, Langfort, & Day, 1982).

In summary, behavioral and cognitive objectives were achieved as shown by improved results on observational instruments, anecdotal observations, and posttesting. These results benefited all participants involved. Teachers, parents, and students increased their knowledge and improved their attitudes regarding mathematics problem-solving approaches.

Recommendations

The writer recommends that educators extend their knowledge of innovative mathematical approaches through exploration and collaboration of ideas. Teachers of young children also need to utilize methods of presentations which involve transferring concrete examples into abstract knowledge. A unified philosophy among kindergarten, first, and second grade teachers regarding mathematics problem-solving approaches encourages continuity in skill development. The writer plans to continue these approaches and present ideas to include second grade teachers, parents, and students as well. Therefore, students will be able to continue to develop mathematical skills without interruptions and contradictions.

Dissemination

The practicum results will be shared with the school's kindergarten, pre-first, first, and second grade teachers. Also, the writer will share practicum information with the primary specialist, mathematics competitions director, teacher of learning disabilities, and mathematics contact person. The writer had already shared some implementation ideas of the practicum with the school's mathematics contact person, who had indicated interest in the findings of the practicum.

Parents, educators, and students have reacted positively to the implementation process. The improvement in students' mathematical abilities as well as teachers' presentation strategies have resulted in positive attitudes towards the innovative concepts introduced. Abstracts will be distributed to educators and other professionals in various schools and organizations, so the positive results can be shared by a wider population.

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APPENDIX A

SOCIOGRAM

NOTE: Underlined students indicate students who did not initiate interaction during mathematics lessons.

Sociogram Question: Ask each student to name another student he works with in the classroom to solve problems during mathematics lessons. Record on list below.

Student Name	Name of student he works with to solve problems during mathematics lessons

Note: After all data is collected, sociograms will be plotted.

Week 4

Teacher A

Jennifer B. <-- Nick

Cheryl --> Eva --> Jennifer C.

Franklyn <-> Alex

Julie <-- Junior

Michael

Chris <-- Tom

Jackie <-- Kelvin

Dawn --> Jamie <-- Eric

Tony

Monica

Anna

Darrick

Cliff

Crystal

Josué

Teresa

Jennifer A.

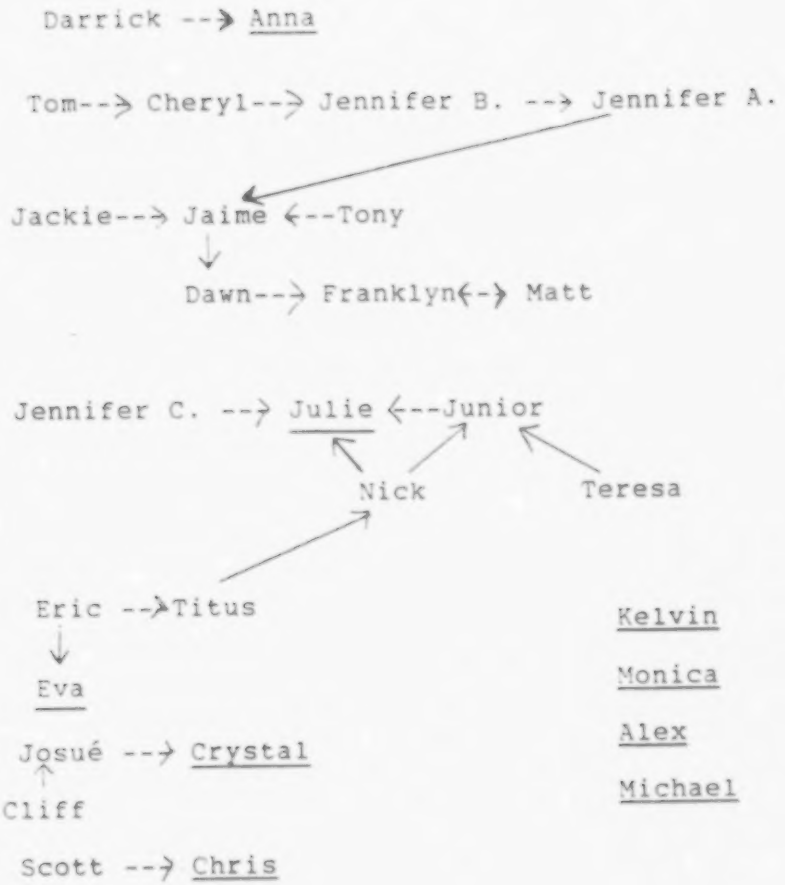
Titus

David

Scott --> Matthew

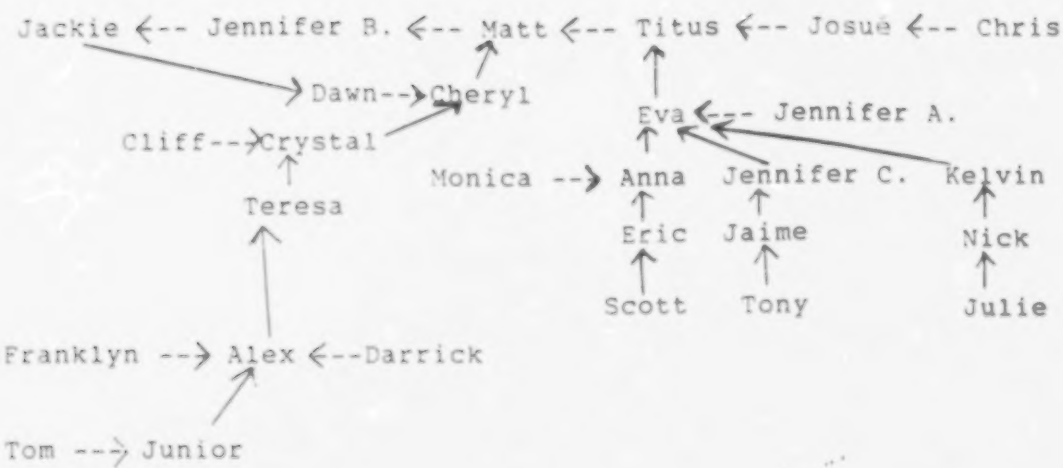
Week 8

Class A



Week 14

Class A



APPENDIX B

STUDENT OBSERVATIONAL CHECKLIST
(Developed by Miranti R. Murphy)

Student Observational Checklist

Student Activities	Yes	No
Students interact with each other during mathematics lessons.		
Students use manipulatives to solve mathematics problems.		
Students participate in group problem solving activities.		
Students offer teacher alternative solutions to mathematic problems.		
Students work independently to solve problems.		
Students performance indicate deductive reasoning abilies.		
Students ask questions freely during mathematics lessons.		
Students cooperate efficiently and effectively to solve mathematical problems.		
Students show abilities to relate mathematical functions to everyday situations and practical applications.		
Students demonstrate understanding of mathematical functions and symbols.		
Students show abilities to think critically.		
Students show interest in exploring mathematical concepts.		

Note: Specific examples of checklist activities will be documented separately as anecdotal observations.

APPENDIX C

TEACHER OBSERVATIONAL CHECKLIST
(Developed by Miranti R. Murphy)

Teacher Observational Checklist

Teaching Strategies	Yes	No
Teacher introduces manipulatives to explain mathematics concepts.		
Teacher encourages active participation during mathematics lessons.		
Teacher uses effective questioning skills during mathematics problem solving activities.		
Teacher encourages freedom of students to explore their environments during mathematic lessons.		
Teacher allows cooperative learning of students.		
Teacher discusses meanings and practical applications of mathematical functions.		
Teacher listens to student concerns and suggestions on mathematic lessons.		
Teacher uses pictorial representations of abstract mathematical concepts.		
Teacher explains abstract concepts through utilization of everyday situations and familiar objects.		
Teacher encourages teamwork and group discussions during mathematics lessons.		
Teacher uses attention directing tools to focus students' thinking.		

Note: Specific examples of checklist strategies will be documented separately as anecdotal observations.

APPENDIX D

TEACHER INTERVIEW CHECKLIST
(Developed by Miranti R. Murphy)

Teacher Interview Checklist

Teacher Attitudes and Observations	Yes	No
Teacher reveals collaborative efforts with fellow teachers on innovative mathematical approaches.		
Teacher show satisfaction with practicum implementation procedures.		
Teacher expresses enthusiasm in learning new approaches to mathematical problem solving.		
Teacher notices improvement in students' mathematics abilities.		
Teacher observes parental support and enthusiasm with innovative teaching techniques in mathematics.		
Teacher shows familiarity with innovative teaching techniques in mathematics.		
Teacher expresses improvement of mathematics curriculum.		
Teacher notices improvements in students' interest in mathematical functions.		
Teacher notices improved classroom participation during mathematic lessons.		
Teacher indicate comfortability in using innovative strategies to teach higher level mathematics.		

APPENDIX E

TEACHER AND EARLY CHILDHOOD FACULTY QUESTIONNAIRES

Developed by Miranti R. Murphy

APPENDIX E

Teacher Questionnaire

		Yes	No
1.	Have you gained sufficient knowledge of problem solving and critical thinking strategies to effectively apply these strategies during your mathematics instructions?	___	___
2.	Are you satisfied with the manipulatives provided during the implementation of this practicum on problem solving mathematics strategies?	___	___
3.	Have your students become more involved in mathematics since implementation of this program?	___	___
4.	Do you feel comfortable teaching higher level mathematics using innovative approaches?	___	___
5.	Is the problem solving program implemented challenging for your students?	___	___
6.	Do your students find problem solving interesting?	___	___
7.	Are you satisfied using cooperative learning and questioning activities during mathematics lessons?	___	___
8.	Do you like the new critical thinking approach to problem solving better than the approach you have been using?	___	___
9.	Do parents react positively to teaching higher level mathematics skills using creative thinking skills?	___	___
10.	Are you satisfied with the skills covered during implementation of this practicum?	___	___

Early Childhood Faculty Questionnaire

		Yes	No
1.	Do you like the new critical thinking approach to mathematics problem solving?	___	___
2.	Are teachers demonstrating effective teaching skills during mathematics lessons?	___	___
3.	Do you prefer the new creative thinking approach to the previous workbook-oriented, drilling approach used by teachers?	___	___
4.	Do students react positively to problem solving strategies and cooperative learning?	___	___
5.	Do you feel that students are grasping higher level thinking skills through the use of manipulatives and pictorial representations?	___	___
6.	Do you feel that manipulatives are important for young children learning mathematics skills?	___	___
7.	Are you comfortable assisting teachers in problem solving activities?	___	___
8.	Are parents reacting positively to this program in mathematics problem solving through explorative learning?	___	___
9.	Would your children benefit from this program?	___	___
10.	Would you like to learn more about problem solving skills and critical thinking strategies in mathematics?	___	___

APPENDIX F

LESSON PLANS CHECKLIST

Developed by Miranti R. Murphy

Lesson Plans Checklist

Observation of content	Yes	No
Plans indicate clear and concise strategies for mathematics lessons.		
Plans show organized and focused questioning strategies for mathematics lessons.		
Plans indicate equal mathematics activities as reading and language activities.		
Plans reveal group projects and cooperative learning strategies during mathematics activities.		
Plans are easy to follow regarding attention directing techniques of critical thinking.		
Plans show clear objectives of mathematics lessons.		
Plans show more explorative learning than workbook activities during mathematics lessons.		
Plans show manipulative activities and pictorial representations involving higher level mathematical concepts.		
Plans emphasize problem solving lessons during mathematics.		
Plans have clear time limitations and directed goals for mathematic problem solving activities.		

APPENDIX G

CONFERENCE FORM CHECKLIST

Developed by Miranti R. Murphy

Conference Form Checklist

Observations	Yes	No
Parents and teachers discuss the importance of mathematics problem solving.		
Parents and teachers discuss the importance of critical thinking skills in mathematics.		
Students show improved mathematical skills.		
Reading and mathematical skills are discussed as equal in importance.		
Conference forms reveal collaborative efforts of teachers and parents in teaching students mathematical problem solving skills.		
Goals for the mathematics curriculum are discussed between parents and teachers.		
Observations of mathematical involvement during mathematics lessons will be included in behavioral objectives.		
Mathematical progress are reported along with reading progress.		
Parents and teacahers are discussed mathematical strategies.		
Parents and teachers reveal positive attitudes in the mathematics curriculum.		